#MoSummit2016

The Innovation Imperative

2016 Director's
Regulatory Summit

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Panelists

Brent Kabler, PhD, Missouri DIFP
Ashley Ramos, Merlinos and Associates, Inc.
Kelsey Brunette, Munich Re

Moderated by:
Angela Nelson, Missouri DIFP

Is Data Mining a Valid Statistical Method?

OR

The value of the <u>p-value</u> and the significance of <u>significance</u>

Brent Kabler, PhD

DIFP
Department of Insurance, Financial Institutions & Professional Registration

Overview

Introduce a few statistical concepts

Causality, spurious relationships, and random relationships

P-value and statistical significance

Big data, data mining and *post hoc* analysis – Departures from the scientific method (or hypothetico-deductive method).

Recent warning by the American Statistical Association regarding the pitfalls of data mining and misuses of the concept of statistical significance.

Uses of Statistics

Prediction → x **PREDICTS** y

V.

Explanation → x **CAUSES** y

While almost the entirety of the natural and social sciences are concerned virtually exclusively with **explanation,** the purpose of insurance rate-making is **prediction.**

ASOP on Causality

"While the actuary should select risk characteristics that are related to expected outcomes, **it is not necessary for the actuary to establish a cause and effect relationship between the risk characteristic and expected outcome** in order to use a specific risk characteristic"

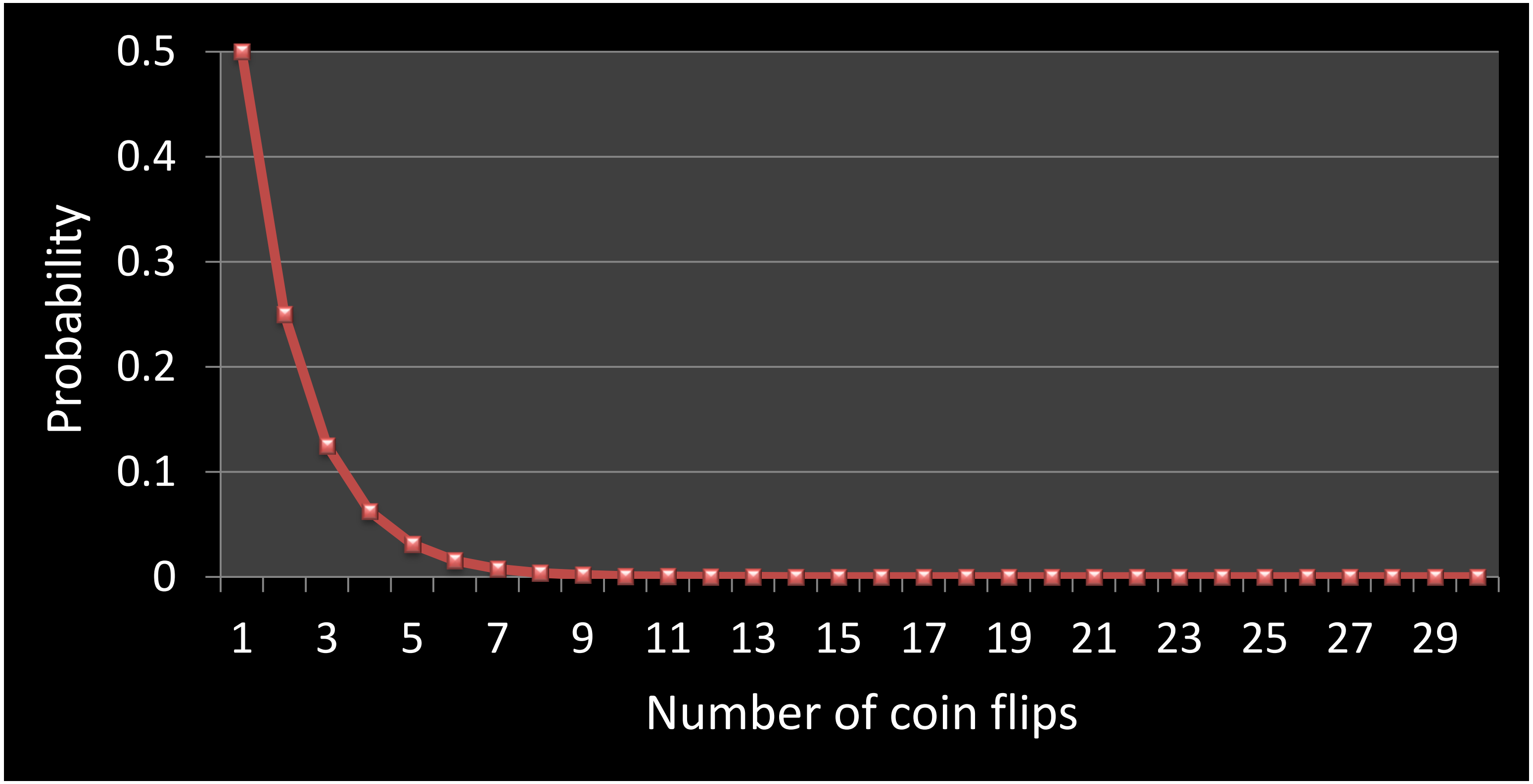
- **Actuarial Standard of Practice No. 12, Section 3.2.2**

(emphasis added)

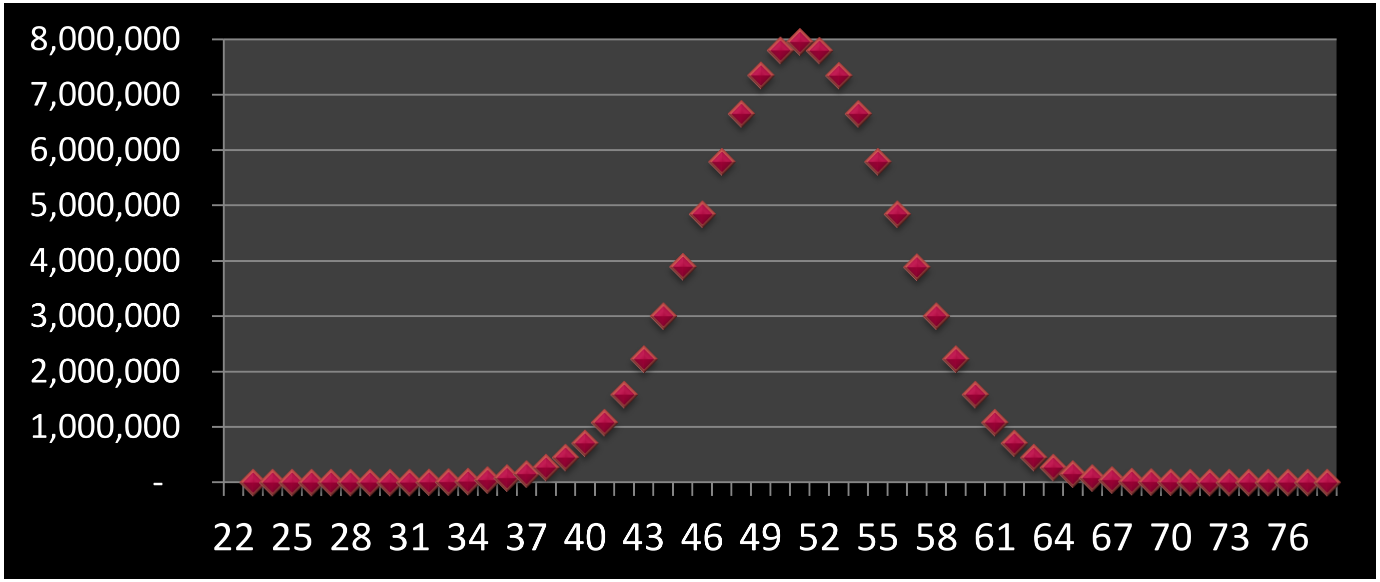
Translation: It is only necessary to ascertain that a relationship exists; it is **NOT NECESSARY** to **UNDERSTAND** the relationship.

P-values & Statistical Significance

Probability of obtaining all “heads” from x flips of a fair coin.



100 million virtual trials of a flip of 100 coins



Highest Number of Heads Obtained	Trial when observed
77	75,400,000
77	88,300,000
77	89,400,000
78	3,530,000
80	38,100,000

Actual probability of obtaining 100 heads in 100 flips of a coin

Probability 100 heads = $(1/2)^{100}$

Or

$$\frac{1}{1,267,650,600,288,299,401,496,703,205,376}$$

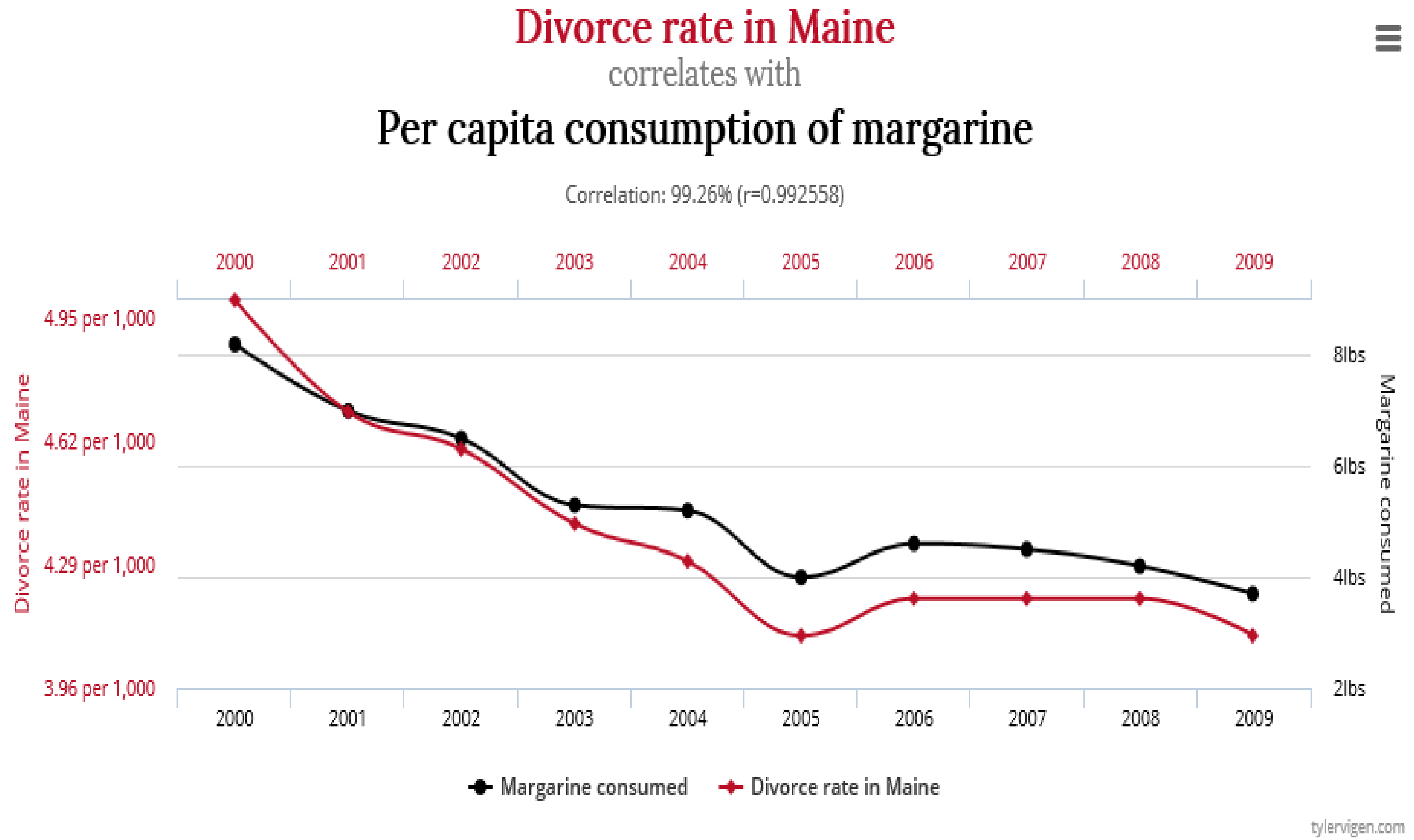
Uses & Misuses of P-values

Hypothetico-Deductive Method

Question in form of testable hypothesis → Create test criteria – pass/fail → Perform test → Evaluate results via previously established criteria → Question in form of testable hypothesis

Data mining – (often) random search for patterns & correlations

Random(?) Correlations



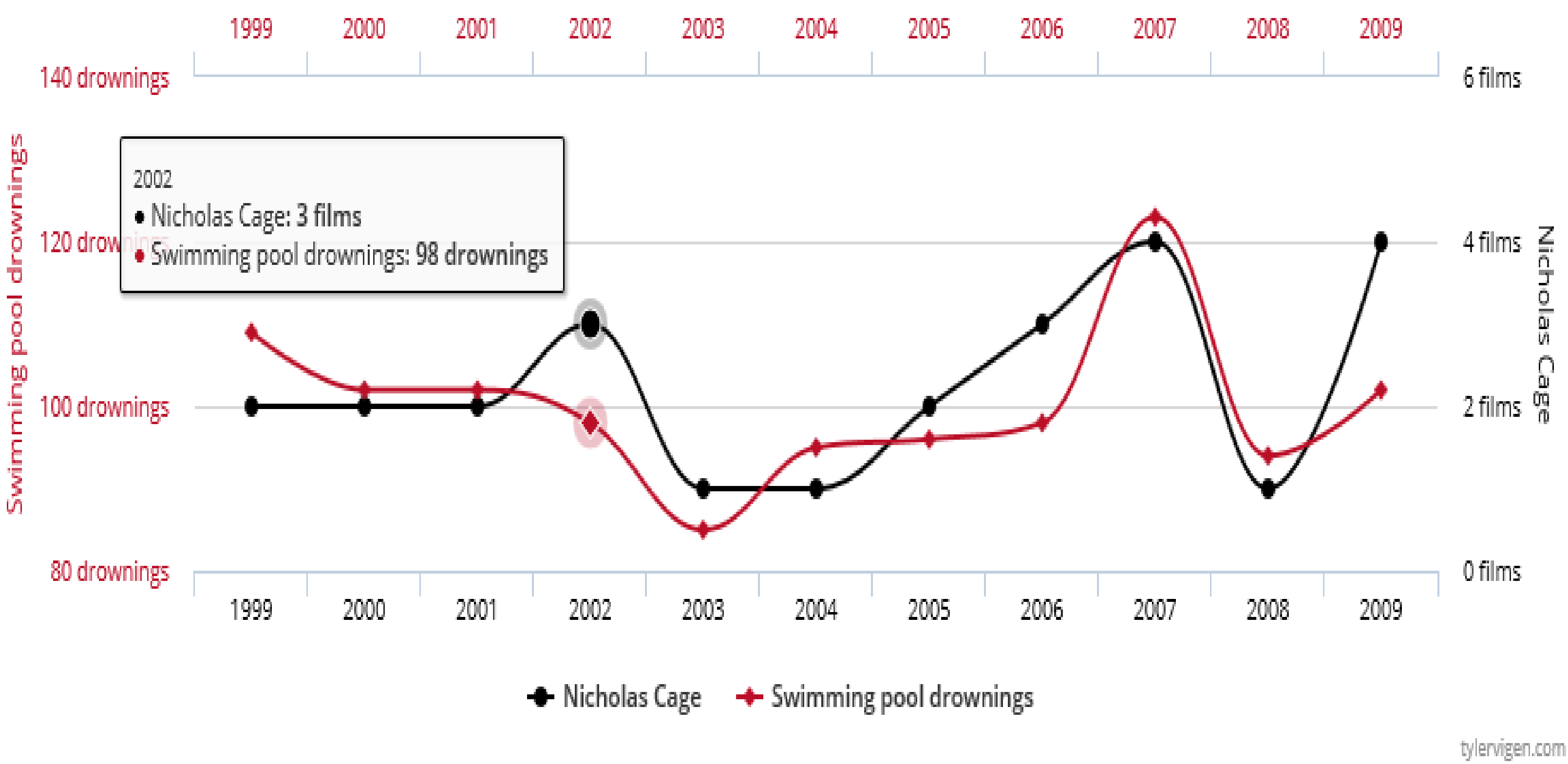
Source: http://www.tylervigen.com/spurious-correlations

Number of people who drowned by falling into a pool

correlates with

Films Nicolas Cage appeared in

Correlation: 66.6% (r=0.666004)

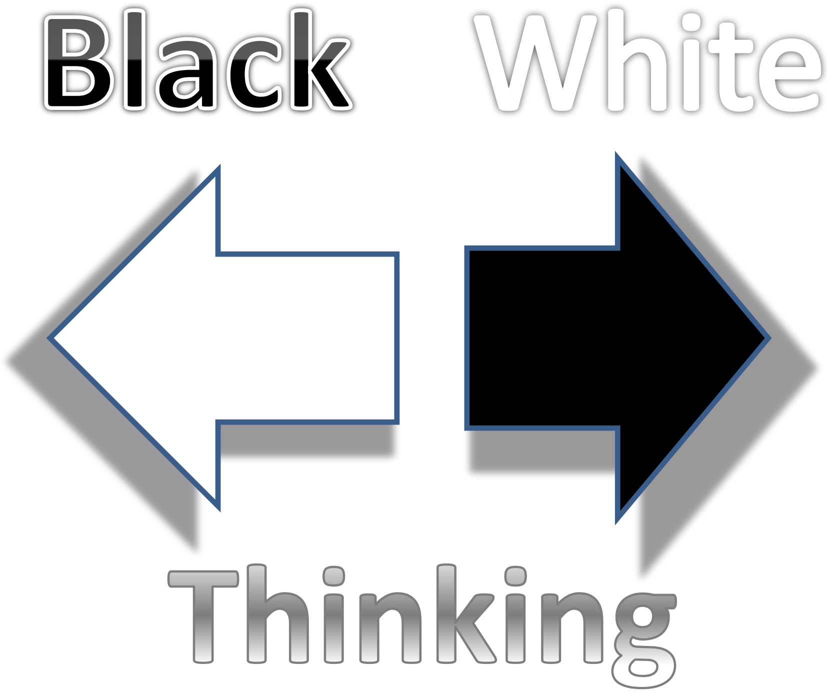


Literal Dead-Ends

Aspirin therapy more likely to result in death than recovery for:

Findings of a recent international study of survivors of heart attack, involving more than 134,000 patients in over 20 countries.

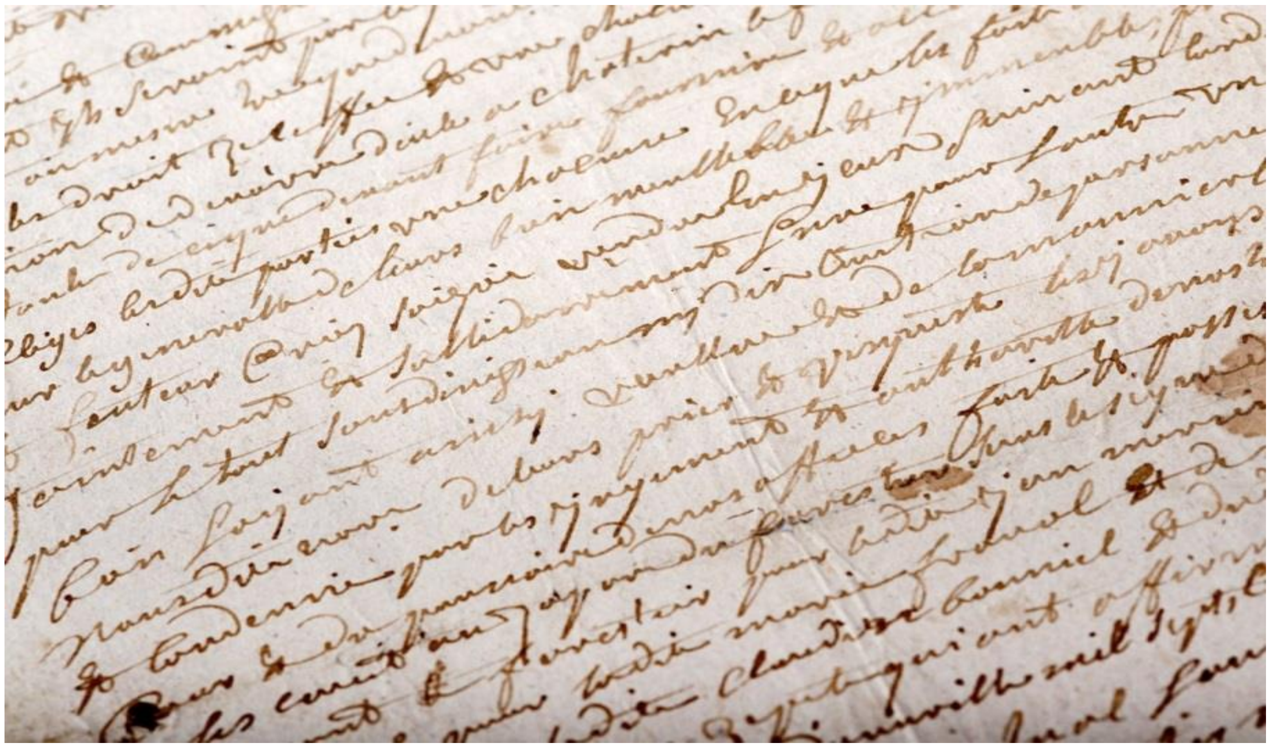
Analytical Dead Ends: A Study in…



Nosek, Brian A., Jeffrey R. Spies, and Matt Motyl. 2012. Scientific Utopia: II. Restructuring incentives and practices to promote truth over publishability. **Perspectives on Psychological Science.** 7(6): 615-631

Post-Hoc Hypothesis Testing

Looking for hidden meanings in text…and finding them.



“Equidistant letter sequences in the book of Genesis.” (Statistical Science, Vol. 9 (1994) 429-438.)

Regulation occurs in the absence of checks considered essential in science

1. Double-blind peer review process
2. Complete transparency
3. Access to research materials and data
4. Replication

Statement by the American Statistical Association

Scientific conclusions ***should not be based only*** *on whether a p-value passes a specified threshold.*

"Researchers should bring many contextual factors into play to derive scientific inferences, including the design of the study, the quality of the measurements, the external evidence for the phenomenon under study [i.e. causal or theoretical knowledge], and the validity of the assumptions that underlie the data analysis" (page 9).

Statement by the American Statistical Association

Proper inference requires full reporting and transparency.

“Cherry-picking promising findings, also known by such terms as data dredging, significance chasing…and ‘p-hacking,’ leads to a spurious excess of statistically significant results…and should be vigorously avoided.”

“Researchers should disclose the number of hypotheses explored during the study, all data collection decisions, all statistical analyses conducted and all p-values computed.”

Implications for insurance regulation?

PREDICTIVE MODELS AND INSURANCE:

A REGULATOR'S PERSPECTIVE

Ashley P. Ramos, FCAS, MAAA

Merlinos & Associates

MERLINOS actuaries consultants

Director's Regulatory Summit 2016
The Innovation Imperative
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AGENDA

- What are Predictive Models?
- Why use Predictive Models in Insurance?
- Regulatory Concerns and Challenges

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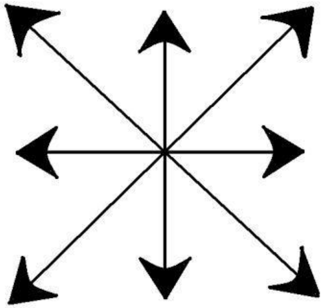
WHAT IS A MODEL?

A description of a system using mathematical concepts and language.

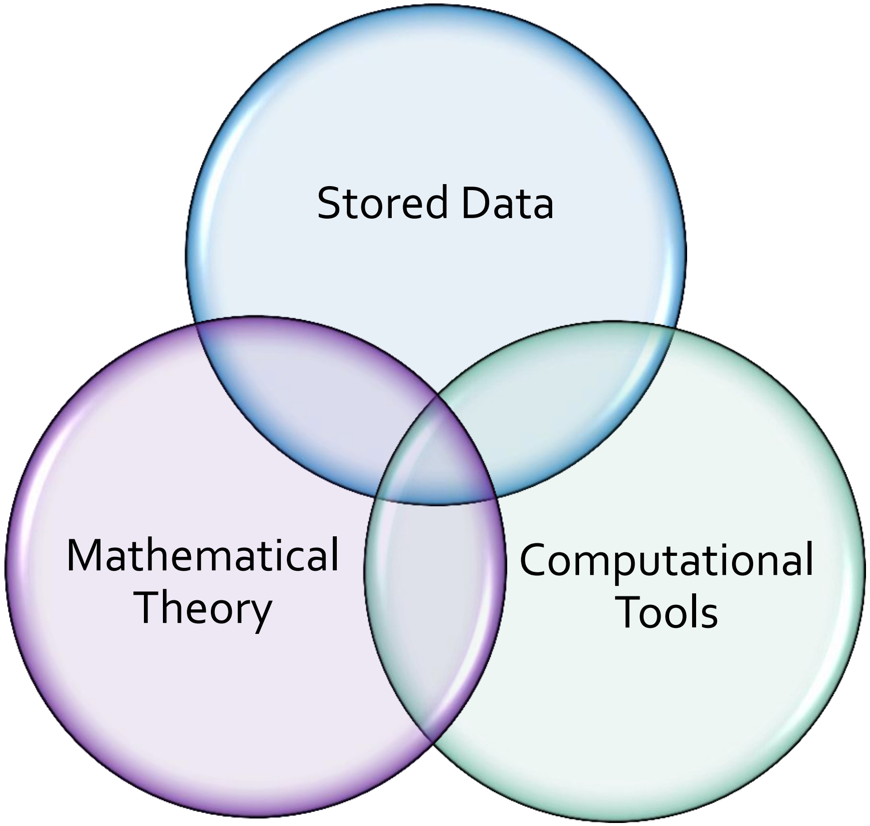
WHAT IS A MODEL?

- Traditional ratemaking methods use one-way analysis.
- One-way analysis looks at the direct relationship one rating factor has in isolation, such as gender, on expected loss costs.

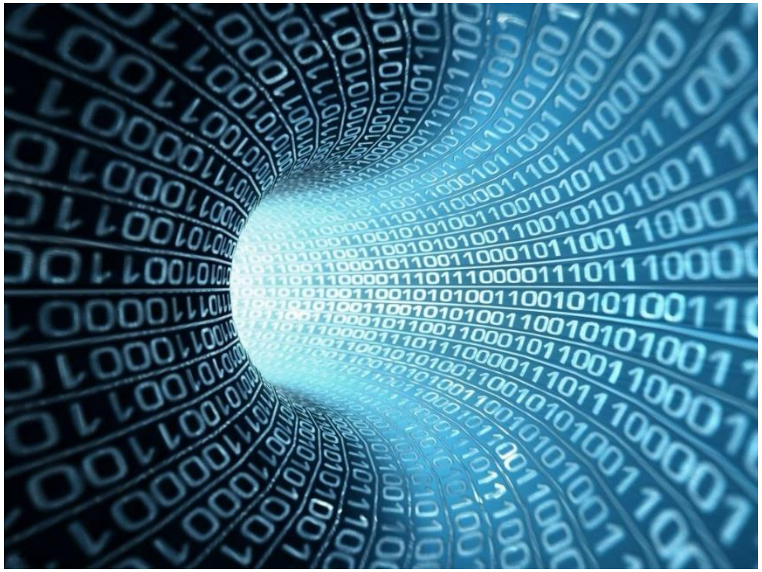


PREDICTIVE MODELING

The process of creating, testing, and validating a model to best predict the probability of an outcome.



AN EXAMPLE: GENERALIZED LINEAR MODELS



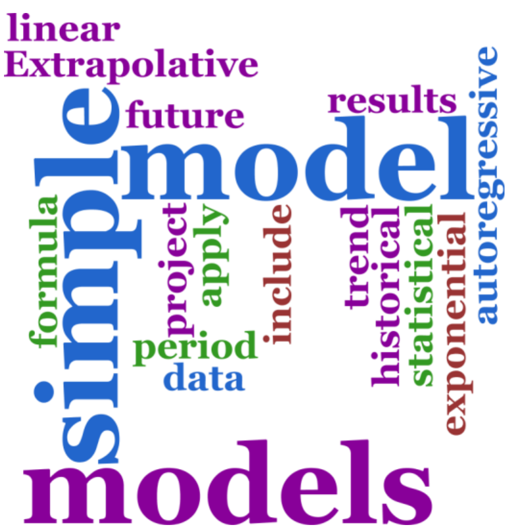
- GLMs are one of the most common types of predictive modeling.
- Unlike traditional one-way analysis, GLMs can consider the impacts of many rating factors simultaneously.

AGENDA

- What are Predictive Models?
- Why use Predictive Models in Insurance?
- Regulatory Concerns and Challenges

WHY USE MODELS IN INSURANCE?

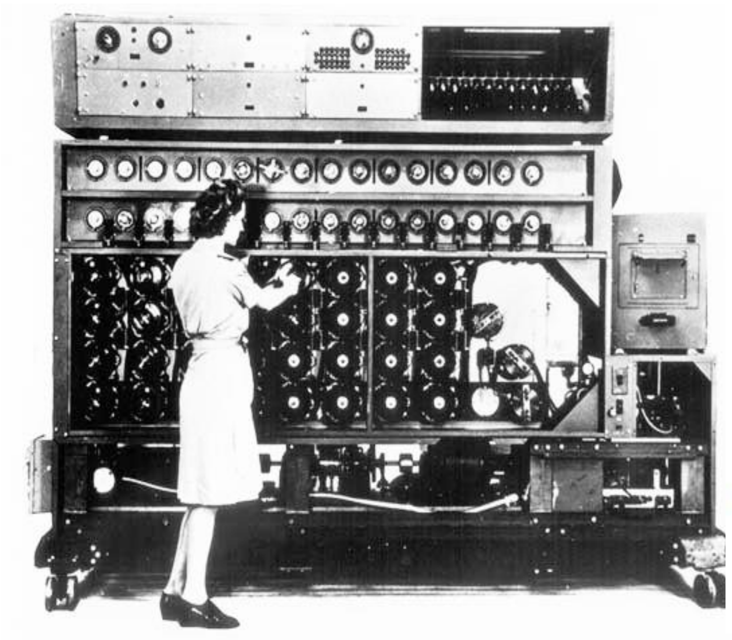
- Minimize human errors and biases when interpreting complex data
- Ensure consistency in decision making and application of results



WHY USE MODELS IN INSURANCE?

Better Data + More Computing Power =

Increased Predictive Accuracy



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REGULATORY CONCERNS

Excerpt from RSMO 379.318:

Rates shall not be excessive, inadequate, or unfairly discriminatory….

Unfair discrimination shall be defined to include, but shall not be limited to, the use of rates which unfairly discriminate between **risks having essentially the same hazard**.

M

REGULATORY CONCERNS

Excerpt from RSMO 379.318:

Risks may be grouped by classifications… or other reasonable methods….

Such standards may measure any differences among risks that can be **demonstrated to have a probable effect** upon losses or expenses.

TRANSPARENCY CONCERNS

Can the regulator:

- See how the model works?
- Be assured that the information will be used consistently and uniformly?
- Understand the information obtained and how it is used?
- Recreate someone's rate from the filed manual?

CHALLENGES REVIEWING PREDICTIVE MODELS

Increased use of 3rd party data and non-traditional variables.

Changing rapidly as machine learning advances and improves.

Gaps between statistical findings and common sense.

CHALLENGES REVIEWING PREDICTIVE MODELS

A model should:

- Demonstrate predictability
- Predict behavior better than the current model
- Be built with adequate testing and validation
- Comply with state regulations

EASING THE REVIEW PROCESS

- Regulators have to review lots of models…**Be helpful!**
- Many filings focus on statistical detail only…don't neglect to **tell the story** of the modeling process.
- Demonstrating a well thought out and controlled modeling process can be **more important** than a hard statistic
- Step back from numbers, and **ask**:
  - ✓ *Do the variables make sense?*
  - ✓ *How is management using my model? Is that appropriate?*
  - ✓ *If I was a regulator, might I have a concern with this?*

PREDICTIVE MODELS AND INSURANCE:

A REGULATOR'S PERSPECTIVE

Ashley P. Ramos, FCAS, MAAA

Merlinos & Associates

MERLINOS actuaries consultants

Thank you!

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Autonomous Vehicles

Director's Regulatory Summit

October 13, 2016
Kelsey Brunette – Ideation Analyst
Munich Reinsurance America, Inc.

Munich RE

Image credit: Backchannel, The View from the Front Seat of the Google Self-Driving Car, 5/11/15

Agenda

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1. **AV 101**
   - **Who** is making autonomous vehicles?
   - **What** are autonomous vehicles?
   - **Why** should we encourage autonomous vehicles?
   - **How** are autonomous vehicles being deployed?
2. **Tech**
3. **Regulation**
4. **Underwriting**
5. **Impact**

Who - OEMs

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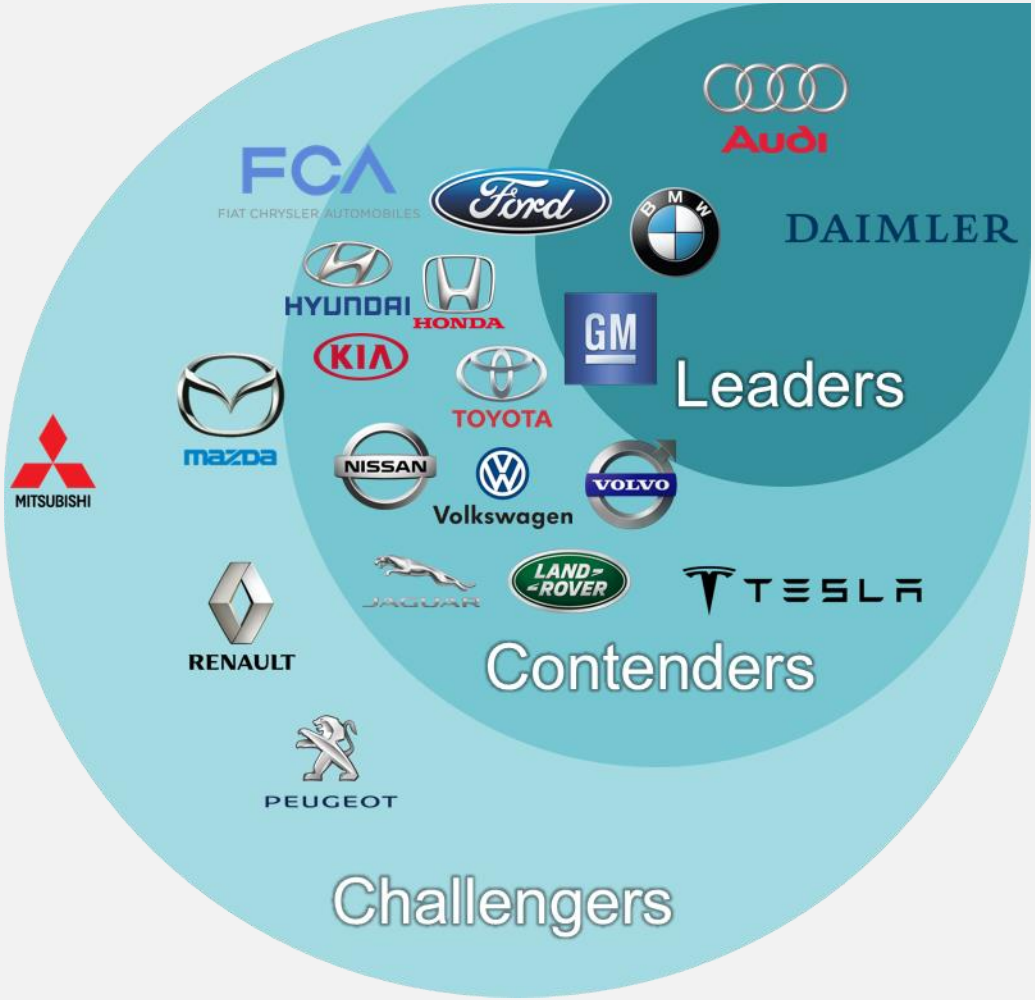
- Original equipment manufacturers (OEMs) used to focus on semi-autonomous capabilities (ADAS systems)
- GM, Ford, and other OEMs have made key partnerships and invested heavily in acquiring talent
- OEMs are participating in lobbying and policy development



Data Source: Navigant Research Leaderboard Report: Autonomous Vehicle OEMs, 2015

Who – Tech Companies

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Whether looking to manufacture cars or just write software, partnerships with tech giants is a key factor in the future of AV development

Source: CB Insights, 33 Corporations Working on Autonomous Vehicles, 8/11/16

Who – Startups

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AVs are not only for the Fortune 500

NAUTO

OTTO

nauya

drive.ai

cruise

Varden Labs

nuTonomy

EASY MILE

Auro Robotics

LOCAL MOTORS

Source: CB Insights, Who's Who in the Rise of Autonomous Driving Startups, June 9, 2016; CB Insights, 5 Companies Working on Driverless Shuttles, 7/ 21/16

What – Terminology

Driverless, **Highly-Automated Vehicle (HAV),** Autonomous, Self-Driving	
Autonomous	**Semi-Autonomous** Advanced Driver Systems (ADAS) Tech that takes over some of the responsibilities of driving. Examples include automatic braking, lane keeping and adaptive cruise control.
	Autonomous Vehicle Tech that takes over all the responsibilities of driving. Examples include the Google Car project and low speed autonomous shuttles.
Connected	**V2X Technology (Connected Vehicles)** Tech that allows devices to speak to each other. Examples include cars talking to each other, or cars talking to stop lights.

Source: Munich Reinsurance America, Inc., 2016

What – Autonomous Vehicle Levels

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Rejected		Adopted	
National Highway Transportation and Safety Administration **NHTSA**		Society of Automotive Engineers **SAE**	
0	No autonomy	0	No autonomy
1	Vehicle takes over one aspect of driving, ex: adaptive cruise control	1	Driver assistance program controls either steering or acceleration
2	Vehicle combine two or more level 1 systems, ex: ACC with lane centering	2	Driver assistance controls both steering and acceleration
3	Driver is expected to retain occasional control	3	Automated system controls, human driver expected to intervene
4	Vehicle controls operation from origin to destination	4	Automated system controls, human drive not expected to intervene
		5	Automated system controls under all roadway and environmental conditions

Why – Humans vs Machines

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Humans

Field of view: ~120 degrees
Distance: 30 meters ahead

Autonomous Vehicles

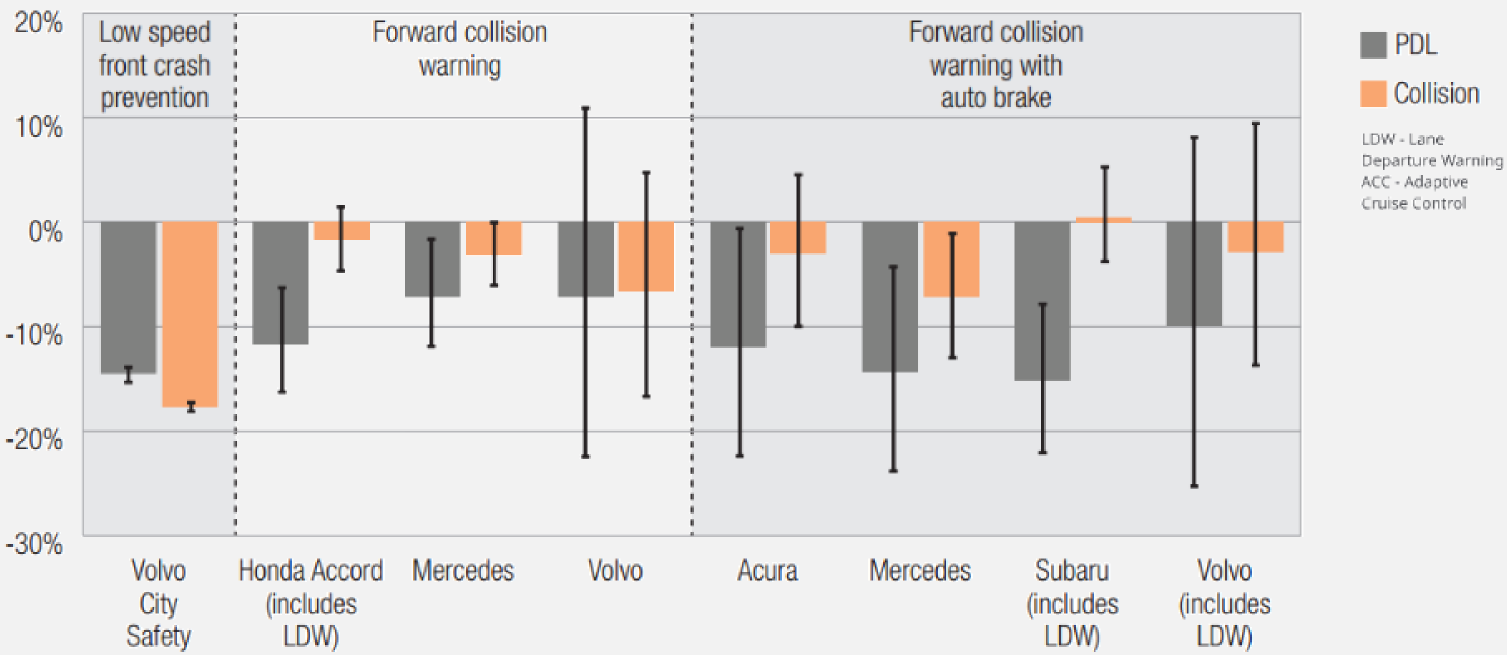
Field of view: 360 degrees
Distance: 300 meters ahead

Source: Munich Reinsurance America, Inc., 2016

Why – Automation Makes a Difference

- According to NHTSA, roughly 90% of accidents are caused by human error
- By reducing driver error, AV technology is predicted to significantly reduce the number of motor vehicle accidents

Figure 1: Changes in physical damage claim frequency for front crash prevention systems



Source: NHTSA, Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey, 2/2015; IIHS, 2015

Why – NHTSA's Call to Action

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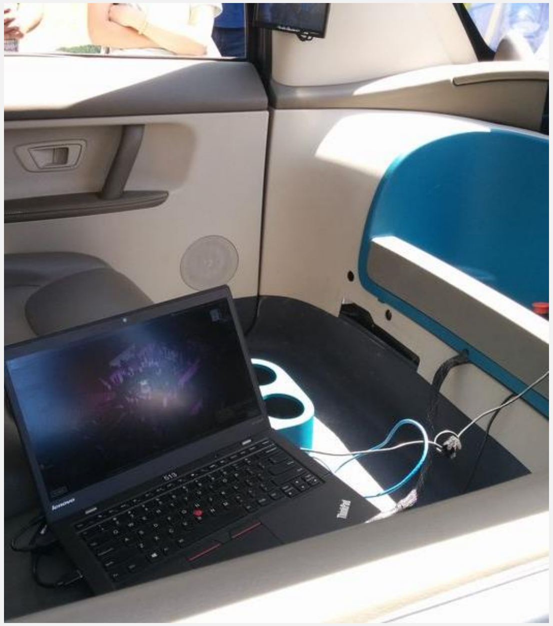
- In 2015, vehicle miles traveled (VMT) increased 3.5% over 2014, the largest increase in nearly 25 years.
- There were 35,092 fatalities as a result of vehicle crashes in 2015, ending a 5-decade trend of declining fatalities with a 7.2% increase in deaths from 2014.
- The last single-year increase of this magnitude was in 1966, when fatalities rose 8.1% from the previous year.

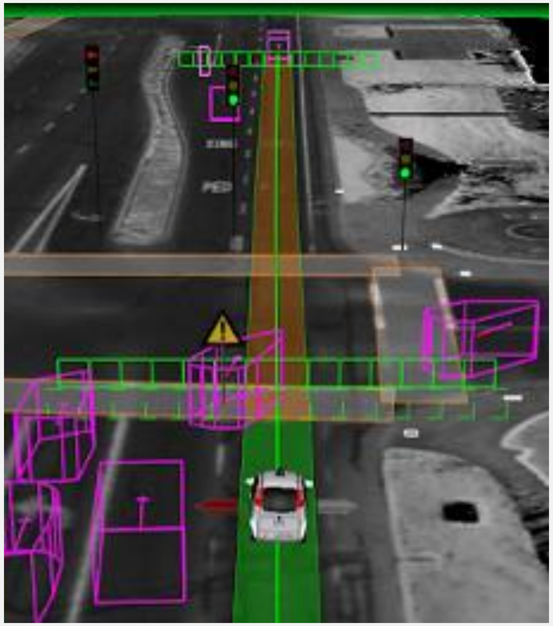
US Department of Transportation (DOT), NHTSA, and the White House are issuing an **unprecedented call to action** to involve a wide range of stakeholders in helping determine the causes of the increase.

Source: NHTSA, Traffic Fatalities Up Sharply In 2015, 8/20/16

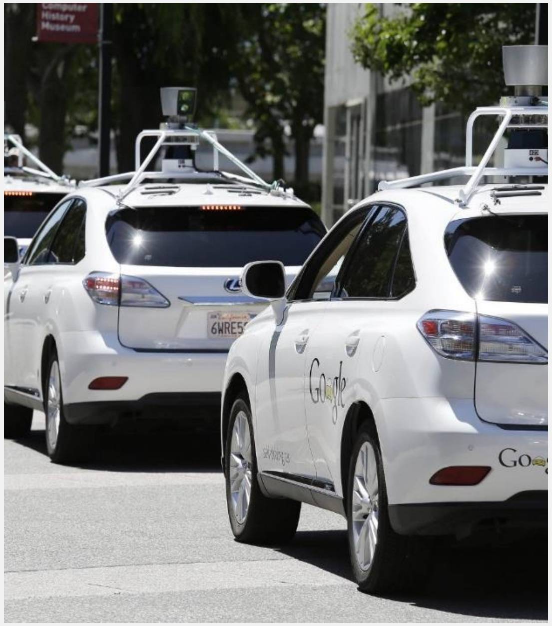
How – Differences in Philosophy



- Steering wheel or no steering wheel?
- Some believe that people will never be able to successfully take back control of steering



- Fully mapped or deep machine learning?
- Some AV teams try to cover every situation, others are teaching the machine to think for itself



- Direct to consumers or commercial?
- Manufacturers are now focusing on releasing vehicles as fleets

Image Credits: The Verge, Take a Look Inside Google's Cute Little Self-Driving Car, 7/13/15, Backchannel, The View from the Front Seat of the Google Self-Driving Car, 5/11/15; Forbes, to Rival Google's Driverless Cars, German Carmakers Eye Nokia's Here, 5/7/15

How – Rate of Adoption

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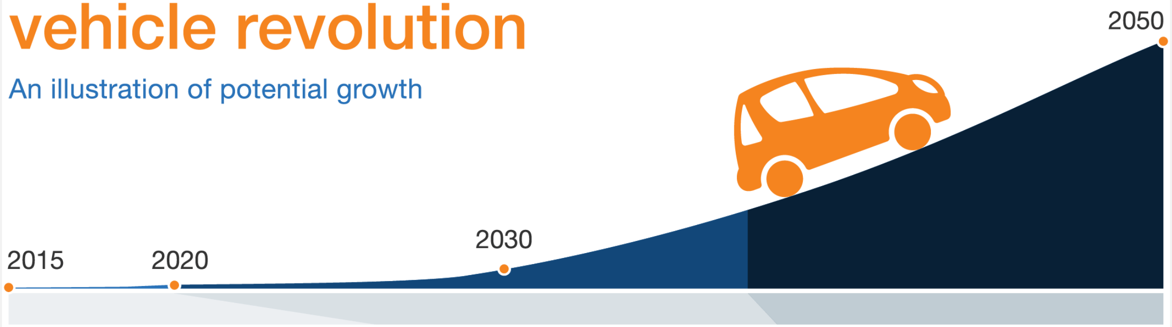
The self-driving vehicle revolution

An illustration of potential growth



Era 1: Fully autonomous vehicles (AVs) being developed for consumers	Era 2: Consumers begin to adopt AVs	Era 3: AVs become the primary means of transport
1 AVs are already a reality in industrial fleets	4 The after-sales service landscape is reshaped	7 AVs free up to 50 minutes a day for drivers
2 Car OEMs begin to assess strategic impact	5 Insurers shift from covering individuals to covering technical failures	8 Parking space is reduced by billions of square meters
3 New mobility models begin to emerge	6 Supply chain and logistics are redefined	9 Vehicle crashes fall by 90%, saving billions of dollars
		10 AV technology accelerates development of robots for consumer use

Source: McKinsey & Company, Ten Ways Autonomous Driving Could Redefine the Automotive World, 6/2015

Tech – The Basics

Sensors
- Ex: blind spot detection

Cameras
- Ex: lane keeping and sign reading

Radar
- Ex: measuring distance between cars for adaptive cruise control

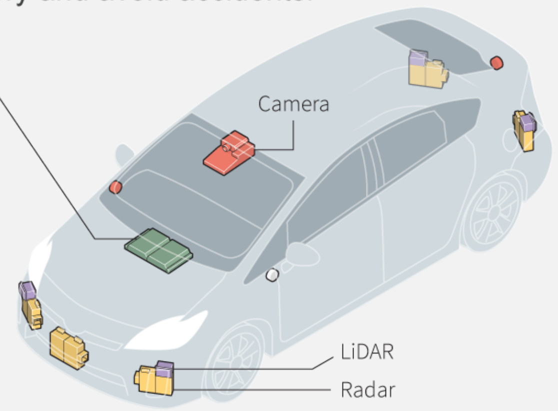
LiDAR
- **L**i**g**ht **D**etection **a**nd **R**anging
- 8 to 60 lasers pointing in every direction

Processor

How self-driving cars see the road

Autonomous vehicles rely on a host of sensors to plot their trajectory and avoid accidents.

Multi-domain controller
Manages inputs from camera, radar, and LiDAR. With mapping and navigation data, it can confirm decisions in multiple ways.



Camera
Takes images of the road that are interpreted by a computer. Limited by what the camera can "see".

Radar
Radio waves are sent out and bounced off objects. Can work in all weather but cannot differentiate objects.

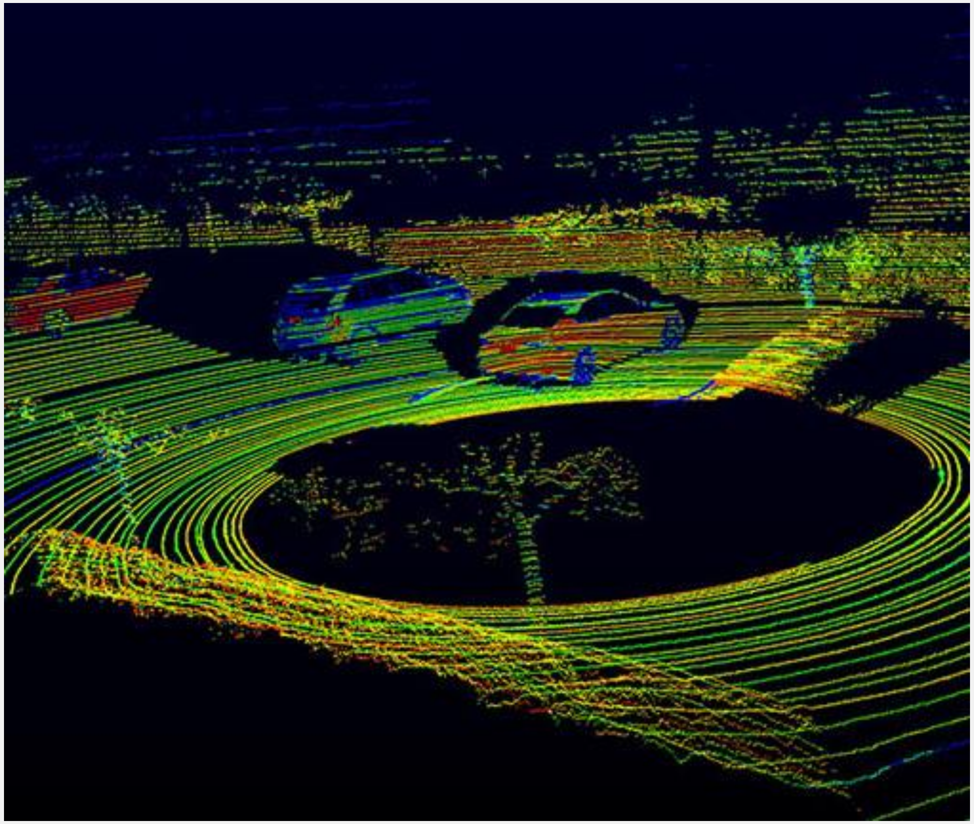
LiDAR
Light pulses are sent out and reflected off objects. Can define lines on the road and works in the dark.

Source: Delphi

Image Credit: Reuters, How Google is Shaping the Rules of the Driverless Road, 4/26/16

Tech – LiDAR

- Laser based detectors that generate 300,000 to 2,200,0000 data points per second
- LiDAR systems range from having 8 to 60 lasers spinning in all directions to complete high-resolution, 3D data
- Leading manufacturer Velodyne received $150 million investment from Ford and Baidu



Source: Traffic Technology Today, Velodyne Receive Substantial Investments from Ford and Baidu, 8/17/16

Tech – Costs of Technology

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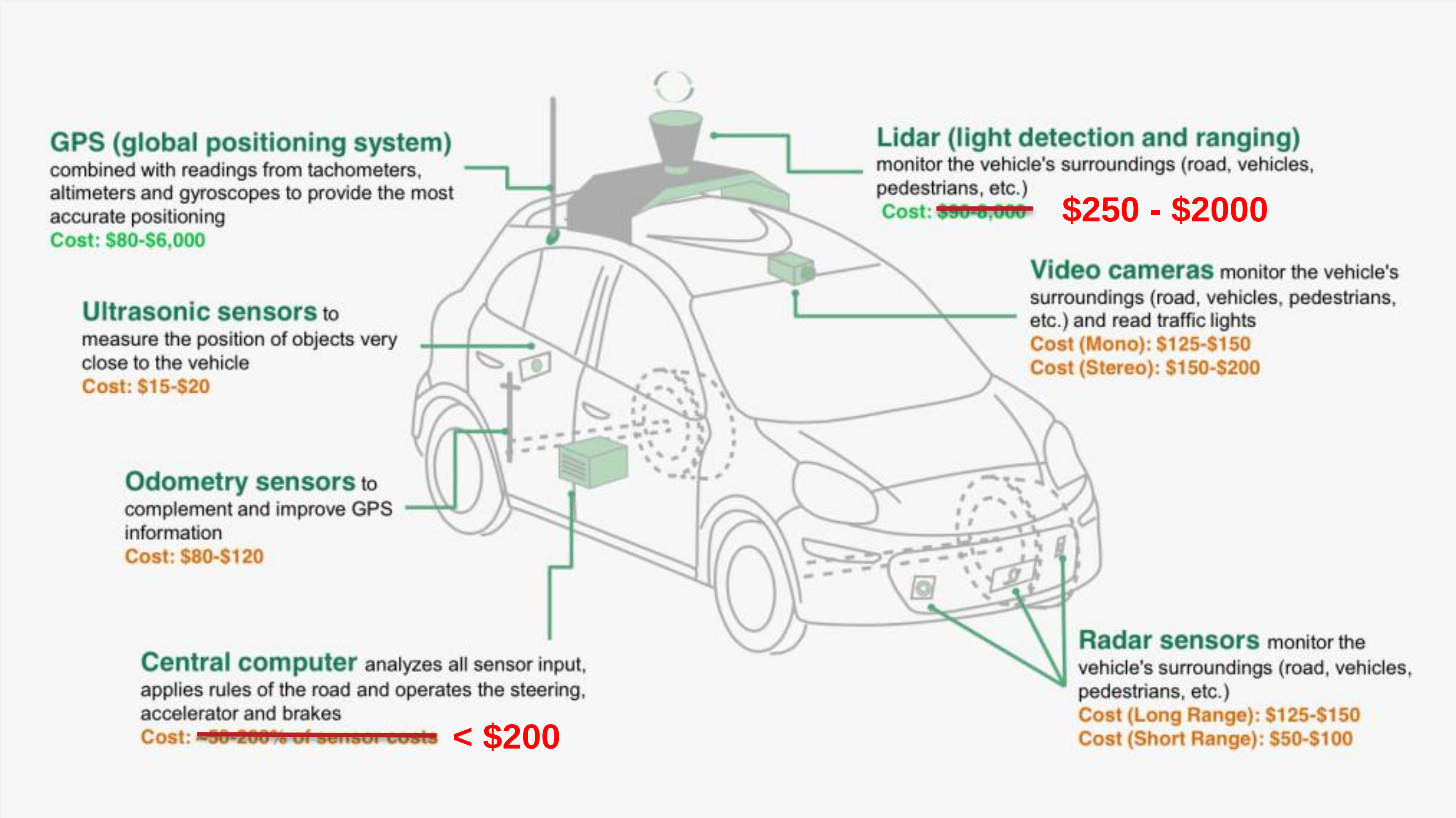

Source: BCG, Revolution in the Driver's Seat: The Road to Autonomous Vehicles, 4/21/15; Spectrum, Israeli Startup Innoviz Promises $100 Solid-State Automotive Lidar by 2018, 9/9/16; Fortune, Nvidia Shows Off New AI Computer for Baidu's Self-Driving Car, 9/13/16, Image credit: Wired, Turns Out the Hardware in Self-Driving Cars is Pretty Cheap, 4/22/16

Tech – Overview of Timeline

Manufacturer	Target Year	Target Achievement	Announcement Date
Tesla	Q4 2017	Level 4 better than human	12/21/15
NuTonomy	2018	Driverless taxis	5/24/16
Delphi/Mobileye	2019	Off the shelf level 4 system	8/23/16
Baidu	2021	Mass produce level 4	6/2/16
Ford	2021	Mass produce for ridesharing	8/16/16
BMW	2021	Self-driving electric vehicle	5/12/16
Ford	2025	Mass produce for consumer	8/12/16

Source: Electrek, Elon Musk On Tesla Fully Autonomous Car: 'What We've Got Will Blow People's Minds, It Blows My Mind . . . It'll Come Sooner Than People Think', 8/3/16; Wsj, Self-driving Car Startup Nutonomy Raises $16 Million In Funding, 5/24/16; The Verge, Delphi and Mobileye are Teaming Up to Build A Self-driving System By 2019, 8/23/16; Wsj, Baidu Plans to Mass Produce Autonomous Cars In Five Years, 6/2/16; Reuters, Ford Plans Self-driving Car For Ride Share Fleets In 2021, 8/16/16; Electrek, Bmw will Launch the Electric and Autonomous Inext In 2021, New I8 In 2018 and Not Much In-between, 5/12/16

Regulation – New Federal Policy

- Federal Model Policy released 9/20/16
- The DOT and NHTSA have released an extensive document highlighting policy to cover the next year for:
  - How DOT will regulate using current tools
  - How DOT hopes to regulate using new tools

"We do not intend to write the final word on highly automated vehicles here. Rather, we intend to establish a foundation and a framework upon which future Agency action will occur."

Source: NHTSA, Federal Automated Vehicles Policy, 9/20/16

Regulation – What This Means for Insurance

- The DOT has tasked state departments have been tasked by the DOT to proactively address liability
- The DOT stated they are likely to form a commission to advise the state departments on specific issues
- The committees formed by states to address all AV issues are advised to have state DOI participation

2017 will have more legislative movement regarding AVs that address deeper and more complex issues than whether or not the state will allow AV testing

Source: NHTSA, Federal Automated Vehicles Policy, 9/20/16

Underwriting - Shifts in Liabilities and Premiums

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Transition to full vehicle autonomy

Varying degrees of impact over time

Auto liability	Likely to shrink
Cyber risk tech E&O/IoT	Likely to increase
Products liability	Likely to increase
Auto physical damage	Likely no material change
Equipment breakdown/warranty	Likely to increase
Product recall	? Likely to increase

Source: Munich Reinsurance America, Inc., 2016

Impact – Other Industries

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- OEM'S
- HOSPITALS
- FIRST RESPONDERS
- TELECOMMUNICATIONS
- URBAN PLANNERS
- MASS TRANSIT MANUFACTURERS AND OPERATORS
- ELECTRIC GRID
- CONSUMER ELECTRONICS
- PERCEPTION SYSTEMS
- MATERIALS SCIENCE
- NON-FOSSIL FUEL PROVIDERS
- COAL INDUSTRY
- OIL COMPANIES
- TOURISM UNIONS
- CHIROPRACTIC
- TORT & LIABILITY RELATED LEGAL FIELDS
- TRANSPORTATION REGULATORS
- CRASH TESTING FACILITIES
- DRIVER EDUCATION
- TRUCKING AND FREIGHT
- PARKING LOT OPERATORS
- VENTURE CAPITAL
- VEHICLE FINANCING/LEASING
- MINING
- TRANSPORTATION MONITORING
- BIKE MANUFACTURERS
- RESEARCH UNIVERSITIES
- ENGINEERING PROGRAMS
- AUTO REPAIR FACILITIES
- TRAFFIC INFRASTRUCTURE
- PERSONAL AND COMMERCIAL INSURANCE
- STOCK AND BOND EXCHANGES
- TIRE INDUSTRY
- HUMAN MACHINE INTERFACE
- ARTIFICIAL INTELLIGENCE
- MILITARY
- SOFTWARE DEVELOPERS
- CLOUD COMPUTING
- MOBILE DEVICE MANUFACTURERS
- VEHICLE SALVAGE OPERATIONS
- CUSTOMS AND BORDER PATROL
- AUTO CLAIM LITIGATION
- VEHICLE SUPPLIERS (TIER 1& 2)
- USED VEHICLE DEALERSHIPS

Impact - Risk or Opportunity?

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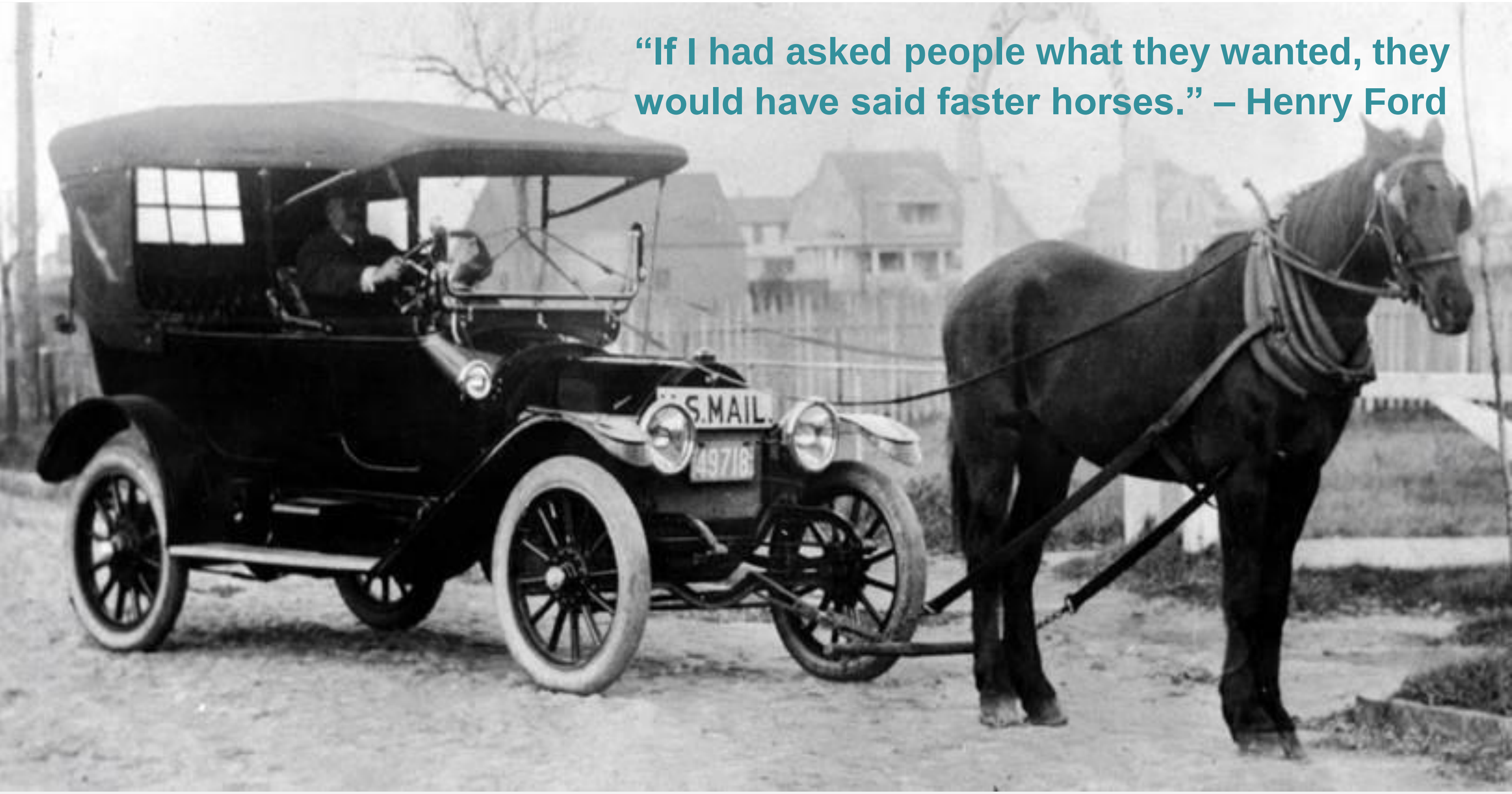

"If I had asked people what they wanted, they would have said faster horses." – Henry Ford

Image: Nantucket Historical Association Library

Thank you for your attention.

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Image credit: Backchannel, The View from the Front Seat of the Google Self-Driving Car, 5/11/15

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Any questions

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